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PATENT AND TECHNICAL TRANSLATION

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DECLARATION

The undersigned, Olaf Bexhoeft, hereby states that he is well acquainted with both the English and German languages and that the attached is a true translation to the best of his knowledge and ability of the German text of PCT/EP2004/005244, filed on 05/15/2004, and published on 12/09/2004 under No. WO 2004/107814 A1.

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

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Flexible Electrical Heating Unit

The invention relates to a flexible electrical heating unit, having a heating device with a flexible support and a heating cord inserted therein, at least one control member for a heating current arranged in at least one heating circuit and a triggering circuit acting thereon.

Such a flexible electrical heating unit is disclosed in DE 33 36 864 C2. There, a temperature intended for continuous operation will be quickly reached in that an increased temperature control value is set in a starting phase. Subsequently, in a transition phase, the temperature control value is lowered continuously or in stages in such as way that no temperature drop occurs at the surface. The continuous operating temperature is not exceeded. A heating unit with a similar triggering circuit for rapidly reaching the desired surface temperature for continuous operation is also disclosed in DE 41 41 224 C2.

A further flexible electrical heating unit which, for example, is designed as a heating pad, is disclosed in DE 44 80 580 C2. A heating current controlled by at least one control member in the form of a triac flows through the heating conductors of a heating cord. The triggering circuit for the control member has a microprocessor, as well as a timing circuit, which is used to control the clock frequency with which a program of the microcontroller operates and which is designed as a watchdog timer for repeatedly stopping the operation of the microprocessor for a period of time which can be set between 0.01 and 3 sec., and to initialize it again. Furthermore, this known heating unit has a safety control circuit, as well as indicator lights. A fail-safe routine with error counters is also implemented in a control

program. The error monitoring device here is designed comparatively elaborately.

A further flexible electrical heating unit for the type mentioned above is disclosed in (not prepublished) DE 102 11 142 A1, in connection with which also various safety arrangements have been made, and a time control circuit for switching off the heating unit is also provided, wherein switch-off times can be fixedly integrated or separately switchable. During extended operations a lowering of the temperature can also take place by appropriately programming a digital circuit arrangement in order to prevent skin burns because of continuously high surface temperatures of the heating unit. It is possible to this end to provide a time-dependent reference variable step-down starting at a defined reference value temperature, or also the switching off of the heating device. Therefore no detailed information has been provided as to the operating phases in which appropriate controls of the heating output are performed.

The object of the invention is based on making available a flexible electrical heating unit of the type mentioned at the outset, by means of which heating conditions at the surface of the heating unit, or of the support, can be set with a higher degree of comfort by a user, wherein the time control circuit simultaneously can be used for meeting safety criteria.

This object is attained by means of the characteristics of claim 1. In accordance therewith it has been provided that the triggering circuit has a time control circuit, by means of which a heating output can be controlled or regulated which, for generating a starting temperature at the surface of the support during a preset initial length of

time, is increased in comparison with a subsequent continuous operating phase, while during the continuous operating phase at most one heating output permissible also for unmonitored operation is set for causing a lower surface temperature of the support than during the initial phase, or wherein a switch-off takes place after the initial length of time.

If, for example, a relatively large heating stage is selected by a user for a correspondingly high surface temperature, this is detected by the control circuit and, by means of the time control circuit, a relatively large heating output is initially released, but only at a level which is acceptable in regard to the safety requirements of the heating unit and the temperature tolerance of a user in order to prevent endangerment of his health, for example. If the initial heat requirement of the user has been substantially satisfied, the heating output is reduced to a degree acceptable for continuous heating operations. Alternatively a complete switching off of the heating output can take place after the initial time period, if a user desires this from the outset and selects a possibly provided appropriate program.

In this connection an advantageous control or regulating option of the heating output results from designing the triggering circuit in such a way that the size and/or length of the increased heating output in the starting phase is controlled or regulated as a function of a heating output manually selected for the continuous heating phase, wherein the desired temperature is related to the continuous operation, and the progression of the heating output in the starting phase is set as a function thereof to an appropriate value. For example, it is advantageous to reach an

appropriate temperature level relatively rapidly by means of a correspondingly high permissible heating current in a starting phase of the initial length of time and then, during the further initial length of time, to maintain it on the same level or to permit it to drop slowly or in stages in order to make a transition to the heating output level of the continuous operating phase, or to perform a complete shut-off toward the end of the initial length of time of, for example, 60 or 90 minutes.

An advantageous construction consists in that the time control circuit acts by means of an output signal on an output-actuating circuit arranged in the triggering circuit, by means of which the control member can be triggered.

In order to achieve, in particular in the initial phase, a progression of the temperature which differs from the continuous operation, it is advantageously provided that a reference variable can be superimposed on the output signal of the time control circuit by means of charging it with a reference variable.

A further embodiment which is advantageous for the construction and the function consists in that the triggering circuit has an insulation monitoring stage for an insulation located between the heating wires contained in the heating cord, a monitoring stage for the interior temperature of the housing, or a limiting stage, or a combination of at least two of these stages, and that the amount and/or length of the generated heating output caused by the effect of the time control circuit is limited in case of a faulty status discovered in at least one of the stages, or the heating output is completely shut down.

A further advantageous embodiment results from the

steps that a further control member, which can be triggered by the triggering circuit, is arranged in the heating circuit and is triggered in case of a faulty state to limit, reduce or shut off the heating current, wherein a useful embodiment consists in that at least one output signal of the stages is used for triggering the further control member.

The construction and the function are furthermore favored in that the, or a further, output signal of the time control circuit is supplied to at least one stage, and that the at least one stage is embodied in such a way that, as in an abnormal state, it acts on the control member, and/or the further control member, for limiting, reducing or interrupting the heating current, or that the, or the further, output signal is applied directly to the further control member for limiting, reducing or interrupting the heating current.

In a reversed manner the steps are advantageous for a simplified construction wherein the output of at least one stage is connected with the input of the time control circuit, and wherein, upon receiving an output signal from the stage, the time control circuit itself transmits an output signal for limiting, reducing or interrupting the heating current.

Moreover, dependable functioning can be achieved in that, for switching off the electrical supply voltage, the time control circuit is brought into an active electrical connection with a switch of the energy supply device of the heating unit, with the triggering circuit, or a component of the latter, or directly with the further control member.

Advantageous setting or control options are furthermore achieved in that the progressions of the heating output for

affecting the surface temperature in respect to size and/or length are stored in a memory as a function of a manually selected output stage or type of operating application, and can be called up for controlling and adjusting the heating output. The various progressions of the heating output useful for a desired heating stage or a desired type of heating operation can then be programmed, in particular in a microprocessor or a microcomputer or micro-controller or ASIC, and can also be reprogrammed or adapted. It is possible in this connection to take different embodiments of the heating unit, for example a heating pad, heating blanket or heated mattress pad, into account in a relatively simple manner.

Here, a further refined control option results in that further progressions are stored in the memory in connection with an output stage change-over during an operating phase, and can be called up as a result of the change-over.

For informing a user more accurately regarding the device status, steps are furthermore advantageous wherein the time control circuit is connected with an indicator device for the status of the time control circuit and/or the device functions.

Additional safety for the operation of the heating unit is obtained in that, in a parallel branch which is located parallel with a control branch of the heating circuit having the at least one control member, a higher order safety shut-off device is provided for shutting off the heating unit in case of a dangerous situation.

The step wherein the heating cord is constructed in such a way that a safety shut-off takes place in case of an excess temperature contributes to safe functioning. In this

case the construction can be advantageously such that the shut-off is triggered in case of a local excess temperature (hot spot). The basic function can be achieved by means of a sort of current safety device and/or temperature safety device. With flexible heating units the reaction or trigger temperature is preferably located in the range between 110°C and 160°C, with especially flexible heating units a different reaction temperature can also be suitable.

The invention will be explained in greater detail in what follows by means of exemplary embodiments, making reference to the drawings. Shown are in:

Fig. 1, a schematic block representation of a first exemplary embodiment of a heating unit,

Figs. 2 to 4, further exemplary embodiments of the heating unit in block representations, and

Fig. 5, an example of two different temperature progressions.

An electric heating unit represented in Fig. 1 has a flexible heating device 10 arranged in a heating circuit 17 and having a flexible heating body or support with a heating cord arranged therein and with a triggering circuit 20 for controlling or regulating a heating current iH flowing in the heating circuit 17. The heating unit can be connected via a power switch 30 to a main current supply 33, for example the electrical network, wherein the supply current is limited by means of a current limiter 31, and a suitable low voltage for the triggering circuit 20 and, if needed, for other installations, is made available by means of a voltage supply element 32.

A heating cord of the heating device 10 is constructed in the customary manner and preferably has two heating

conductors extending coaxially or side-by-side, which conduct the heating current in opposite directions for reducing an electromagnetic field, and are separated from each other with the aid of an insulation having, for example, a negative resistor temperature progression (NTC resistor). For detecting the insulation resistance, an insulation sensor device 11 is arranged at least partially in the heating circuit 17. Following the heating device 10, the heating circuit 17 is separated into a control branch 17.1, having the control member 12, and a parallel branch 17.2 extending parallel with it, in which a safety circuit 14 for shutting off the heating unit is arranged if a dangerous situation arises in the heating device 10, such as a short circuit, for example.

A further control member 13 is arranged in the control branch 17.1, by means of which the heating current iH can be limited, or even completely shut off, in case of a failure, wherein its triggering also occurs via the triggering circuit 20. The two control members 12, 13 are preferably designed as semiconductor switching members, for example as thyristors, or triacs, or switching transistors. Reference regarding the details of the embodiment of the insulation sensor device 11, the control members 12, 13 with their triggering, as well as the safety shut-off device 14, is made to the publication DE 102 11 142 A1 mentioned at the outset, in which details of a suitable design are disclosed. Accordingly, a diode is arranged between the ends of the heating wires remote from the connecting cable, by means of which a half-wave of the heating current iH is blocked during normal operations. If now current of a negative half-wave also flows, this means that the diode is shorted out through

the insulation. Because of the negative temperature progression of the insulation, this electric current component is a function of the temperature of the heating cord, so that it is possible to draw conclusions regarding the temperature of the heating cord via the insulation sensor device 11, wherein spot temperature rises (hot spots), in particular because of a sharp kink, result in a considerable temperature rise in the blocking direction of the diode, which reaches a maximum in case of a short circuit in the heating conductors.

In case of a short circuit in the heating conductors, the safety shut-off device 14 in particular responds, which is fed via a further diode arrangement which lets the short circuit current through. The short circuit current leads to a large temperature rise in resistor elements provided in the safety circuit 14, which are in thermal contact with a temperature safety device and trigger it, and in this way interrupt the supply current for the heating unit.

As essential components, the triggering circuit 20 has a time control circuit 21 with an indicator device 21.1, as well as an output-actuating circuit 25 connected with the latter, through which the control member 12 is triggered. The triggering circuit 20 furthermore has an output stage switch 22 as an essential component, by means of which a user can select a desired temperature. The triggering circuit 20 can furthermore contain a monitoring device 23 for the interior housing temperature of a switch housing, and/or a monitoring circuit in the form of a watch dog device or of a redundant triggering circuit for the further control member 13. The triggering circuit 20 can be realized in part by a micro-controller or microcomputer, or a special integrated

circuit arrangement (ASIC solutions).

The time control circuit 21 has several functions, which can be provided by one or several programs contained in it. Here, an advantageous embodiment consists in that during an initial time period, which is preset or can be fixedly preset (cannot be changed by the user) of preferably between 30 and 120 minutes, for example 60 or 90 minutes, initially a heating output, which is clearly increased in comparison with a selected temperature stage, is generated via the output-actuating device connected to the time control circuit 21 and the control member 12, wherein in a starting phase of the initial time length Delta ta a steep rise of the surface temperature of the heating body or support takes place up to a defined level, in which the safety requirements are still dependably maintained. Then, by means of an appropriate control or adjustment of the heating current iH, the heating output remains at this level for a preset length of time or is slowly reduced. Toward the end of the initial time length the heating output, or the heating current iH, is then controlled or regulated in such a way that a permitted temperature at the surface of the support, which can be selected by the user for a longer subsequent continuous operation phase without a fixedly preset end, or also by means of a time control, of 50°C or 60°C, for example, is not exceeded in order to assure safe operation of the heating device 10 even under unsupervised conditions (for example while sleeping), and also to assuredly prevent health risks, even to a sensitive user.

An example of the progression of the temperature at the surface of the support, which is controlled or regulated by means of the above steps, is represented in Fig. 5. A

maximum surface temperature T_{omax} (in the present case 85°C), which in no case may be exceeded, is reached, for example, after 90 min. or sooner. Thereafter, a lowering of the temperature takes place in accordance with a defined reference variable to a temperature T_{OD} (of, for example 50°C), which is permissible for continuous operation (over several hours), which is also permissible during unsupervised operation (for example during sleep). An intermediate temperature T_z (for example of 65°C), which lies between the maximum surface temperature T_{omax} and the permissible continuous operating temperature T_{OD} is at most exceeded for a length of time Delta tz (for example two hours).

The control or regulation of the heating output by means of the heating current iH can alternatively also take place in such a way that, following the desired progression of the temperature during the initial length of time Delta ta, complete shut-off takes place, wherein the temperature is reduced in accordance with the progression T_{OA}. Such a selection option can be provided, for example, in the output stage switch 22, or a corresponding operating unit.

Furthermore, it is also possible to provide an interval output control or regulation for the above mentioned heating programs, for example for a therapeutic treatment, while observing a maximum temperature limit value after 60 or 90 minutes, for example.

The progression of the output control or regulation, and of the temperature caused thereby on the surface of the support, here complies with a selected temperature stage and is preferably also suitably controllable as a function of a change of a temperature stage, for example as a function of the length of time since switch-on and/or of the selected new

temperature stage in respect to the previous one. It is also possible to provide a preselection option of the mode of operation in the operating unit or the output stage switch 22, such as an interval-like heat treatment for therapeutic treatments, or a sleep mode, for example.

The output stage reduction can take place continuously or in stages in accordance with a preset program progression.

For causing a switch-off, for example after 60 or 90 minutes, it is conceivable to let an output signal of the time control circuit 21 act on the output-actuating circuit 25, on the monitoring circuit 24, the power switch 30, on the monitoring device 23 for the interior housing temperature, or on the insulation sensor device 11, if required along with an insulation monitoring stage 11.1 provided in the triggering circuit 20, or on combinations of these components. In the progression of this the control member 12 and/or the further control member 13 can be addressed. It is also possible to perform a limitation or reduction of the heating output via one or several of these components.

The various progressions can be stored in a memory, for example in the form of progression curves, or tables, wherein they are automatically selected corresponding to the temperature selection via the output stage change-over switch 22, or the operating unit. In particular, it is also safely assured in this way that preset or predeterminable threshold values are maintained in accordance with recognized safety criteria. The operational states of the time control circuit 21, as well as other operational states of the heating unit, can be represented on the indicator device 21.1 in a manner which the user can understand. The selection of the temperature stages, or of a mode of operation, can also be

represented in this way to the user.

As can be further seen in Fig. 1, the time control circuit 21 is in bi-directional connection with the supply element 32 in order to be able to provide the shut-off of the latter, if required. The time control circuit 21 is moreover bi-directionally connected with the output stage change-over switch 22, so that it can detect the temperature selection and, on the other hand, can also cause the switch-off of the output stage change-over switch, for example. Furthermore, the output signals of the time control circuit 21 can also act via the monitoring device 23 for the interior housing temperature and the monitoring circuit 24 on the further control member 13 for limiting, reducing or switching off the heating output. In the other way it is also conceivable that the monitoring device 23 for the interior housing temperature and the monitoring circuit 24 act with their assigned control signals on the time control circuit 21, which then itself acts by means of an appropriate output signal on the control member 12 or the further control member 13 for limiting, reducing or switching off the heating output.

A further exemplary embodiment of the electrical heating unit is represented in Fig. 2. The components identified with reference symbols corresponding to Fig. 1 have corresponding functions, so that reference is made in this regard to the above explanations. With the exemplary embodiment in accordance with Fig. 2, two heating cords, which can be separately controlled, have been placed into the flexible support, for example, so that a first and a further heating device 10A, 10B result. Preferably the two heating devices can be controlled via respective heating circuits 17 in the same way as in the previous exemplary embodiment,

wherein portions of the heating circuit 17 can also be assigned to the two heating devices 10A, 10B together. The triggering circuit 20 correspondingly has an output stage switch 22, or an operating unit, by means of which both heating devices 10A, 10B can be separately selected in regard to the temperature selection. It is also correspondingly possibly by means of the time control circuit 21 to separately preset different progressions of the two heating devices 10A, 10B. This triggering control 20 also has a monitoring circuit, for example, with a watchdog circuit or a redundant control circuit for the further control member 13, as well as a monitoring device 23 for the interior housing temperature, which can be connected in a suitable manner with the time control circuit 21, as explained in the previous exemplary embodiment.

The time control circuit 21 contains a clock frequency change-over circuit 21.1, a frequency divider 21.2, which can be changed over, as well as a logical output device, which makes possible different output signals for triggering the power circuit breaker 12, so that here a separate output-actuating circuit 25 is not required.

When changing the output stages, it is possible via the clock frequency change-over circuit 21.1 or a change-over of the frequency divider 21.2 to preset a change of the time control circuit via the output change switch 22 by means of the time control circuit 21, wherein a combined utilization of the clock frequency change-over circuit 21.1 and the frequency divider 21.2 can also be provided. In this case the output change-over can also be realized by means of a mechanical output change-over device acting directly on the time control circuit 21. The user sets the temperature stage

by means of the output change switch 22 together with the heating device 10A, 10B. The clock frequency change-over circuit and/or the frequency divider 21.2, for example, are simultaneously activated in order to exert an influence on the time control device.

Since the time control circuit 21 is provided with signals from the monitoring device 23 for the interior housing temperature, the monitoring circuit 24 and/or the insulation sensor device 11, namely via the logical output device 21.4, the former can detect the impermissible state, for example when the interior housing temperature or the heating cord temperature are exceeded, and interrupts the heating current iH by means of the control member 12, or reduces it to an effective value. Here, too, the user can be supplied with appropriate status information by means of the indicator device 21.1 of the time control circuit 21.

It is also conceivable here, the same as in connection with the previous exemplary embodiments, to put out an acoustic indication, for example a warning signal.

With the exemplary embodiment in accordance with Fig. 3, the components corresponding to the exemplary embodiment in accordance with Fig. 1 are also identified with the same reference symbols. Again, reference is made to the exemplary embodiment in accordance with Fig. 1, as well as to the exemplary embodiment in accordance with Fig. 2, for their operation and functioning. A temperature regulation is performed in the exemplary embodiment in accordance with Fig. 3 in that an actual value is picked up in the heating circuit 17, namely in the control branch 17.1, by means of a measuring circuit, for example a measuring resistor 15, and is supplied via an actual value circuit 27 to an input of a

comparator embodied in a control stage 29. A primary reference variable, which was made available in particular by the output stage change-over switch 22, is supplied to a further input of the comparator in order to trigger, by means of a reference variable/actual value comparison and an appropriate triggering circuit with an output divider, the control member 12 to regulate the temperature by affecting the heating current iH. Furthermore, the control stage 29 which, for example, is embodied as a micro-controller, is provided with signals from the insulation sensor device 11 via the insulation monitoring stage 11.1, the monitoring device 23 for the interior housing temperature and/or the monitoring circuit 24, wherein, however, in the present case an output of the monitoring circuit 24 is connected directly with the further control member 13.

Now, the time control circuit 21 can, by means of appropriate output signals, affect the reference variable in particular via the reference variable circuit 26 and via a reference value charge device 26.1 in order to influence the heating output as a function of the length of time, or the heating current iH via the control stage 29, in particular in the way explained in connection with the first exemplary embodiment. Furthermore, the time control circuit 21 also triggers the insulation monitoring stage 11.1, the monitoring device 23 for the interior housing temperature, a zero voltage triggering device 28 for assuring defined triggering times, as well as the monitoring circuit 24 and also the power switch 30, wherein these triggering options can also be embodied only in part. Diverse intervening options in the regulation of the temperature are made possible with these steps. Here, too, the user sets the desired temperature, or

an operating mode, via the output stage switch 22, or an appropriate operating unit, by means of which he presets the reference temperature variable or a progression of the reference temperature variable. The electrical voltage supply can also be turned off, if required, by means of the time control circuit 21 acting on the power switch 30. The progressions described in connection with the first exemplary embodiment can be controlled or adjusted by means of the at least partial triggering of the remaining components, and a limitation, reduction or switch-off of the heating current iH can be caused.

With the exemplary embodiment represented in Fig. 4, in which the corresponding components are again identified by the same reference symbols as in the preceding exemplary embodiments, two bi-metal regulators 16.1, 16.2, which have been switched in parallel with each other, are arranged in the heating circuit 17 following the heating device 10, downstream of which again an insulation sensor device 11 or, in its place, a further bi-metal regulator or limiter, or a temperature safety device, are connected. Thereafter the heating circuit 17 again branches off into the control branch with the control member 12, and into the parallel branch 17.2 with the safety shut-off 14. On the input side, the time control circuit 21 is connected to the supply element 32, the output stage switch 22, the monitoring device 23 for the housing temperature, as well as the insulation sensor device 11, or a component replacing it. On the output side, the time control circuit acts on the output-actuating circuit 25, the supply element 32, the power switch 30, the control member 12 and/or the output stage switch 22. The output-actuating circuit 25 and the monitoring device 23 for the

housing temperature are moreover supplied by the supply element 32. Corresponding progressions as described in connection with the previous exemplary embodiment can be at least partially controlled by the time control circuit 21, wherein this preferably is also preset in programs.

The regulation of the heating current iH by means of the two bi-metal regulators 16.1, 16.2 takes place in the way that initially the heating current iH flows through both bi-metal regulators 16.1, 16.2 until the first bi-metal regulator 16.1 is switched off when a lower temperature threshold of, for example 50°C, has been exceeded. Thereafter the heating current only flows through the other bi-metal regulator 16.2 until an upper temperature threshold preset in it of, for example 75°C, has been reached. Then the heating current iH is completely interrupted. Since the other bi-metal regulator 16.2 has been designed with an automatic lock and therefore remains in the opened state, the heating current iH only starts to flow again when the temperature falls below the lower threshold, to that an adjustment to this temperature is made following the initial time length. It is then possible by means of the further bi-metal regulator 11 or the control member 12 to set a limitation, reduction or shut-off of the temperature up to the lower temperature limit. In the course of this the temperature desired by the user is set via the output stage switch 22, as well as via the progression determined by means of the time control circuit 21, as described in connection with the preceding exemplary embodiments. Here, too, the shut-off of the heating current iH, for example, can take place by triggering the power switch 30 by means of an output signal from the time control circuit 21. The heating unit in

accordance with this exemplary embodiment also provides temperature updating adapted to the wishes of a user, wherein various safety criteria can be assuredly maintained.

Switch-off via the described time control circuits takes place in particular by means of uni-polar or multi-polar switch-off devices, for example, while switching off by the user takes place, for example, in an omni-polar manner from the power supply in the customary way.